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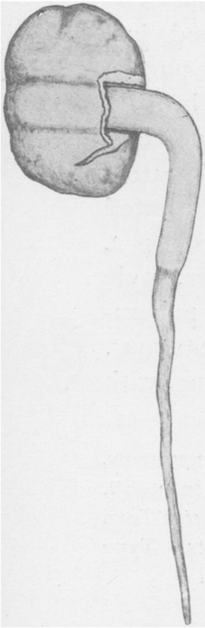
BRIEFER ARTICLES.

POSITIVE GEOTROPISM IN THE PETIOLE OF THE COTYLEDON.

(WITH ONE FIGURE)

IN A former paper[1] on the geotropic responses of young hypocotyls and the cotyledons of some monocotyledons, I showed that the downward curves they execute are in response to stimuli received by the root tip. This note is to report the same phenomenon in yet another category of stem-organs—in the petiole of the cotyledon. The accompanying figure shows a seedling of *Aesculus Californica.* When the buckeye germinates, the first structures to elongate are these petioles, and in whatever position the seed is lying they grow enough to bend in such a way that when the active growth of the root begins it is directly downward. I have observed the germination of the seeds in all cardinal positions and found this true, whether the curve was alike in the two petioles or was accomplished by more rapid growth of either one.



The analogy to the positive geotropism in cotyledons and hypocotyls is close enough to convince one that these petioles act under the influence of the root tip. Measurements of the growing region corroborate this view. In a rather advanced seedling, whose root was already 7^{mm} long at the beginning of the experiment, the growing region was more than 15^{mm} long. It was placed horizontal and left 29 hours, and by that time the tip was aimed almost vertically downward. The most considerable elongation was in zones 6–8, but it amounted to 3^{mm} (measured midway between the convex and concave sides) between the 10^{mm} and 15^{mm} lines. The curve began about the 14^{mm} mark, and had the least radius at about 12^{mm}, but continued toward the tip into zone 6.

In this case there was evidently an apical growing region, consisting partly of root and partly of shoot, which curved where it grew. Likewise in both root and shoot the curvature was at first more largely in the shoot, while before the close of the 29 hours the zone of most rapid elongation had moved forward into the root. So far as concerned its geotropism it behaved as if all root. In older roots the growing region is shorter, as would be expected in correlation with their being decidedly more slender, and the curve is correspondingly nearer the tip. As the cotyledons serve solely as a food store, they remain in or on the ground, where the seed germinates, and there is no later growth with negative geotropism, such as occurs, for instance, in the hypocotyl of Lupinus.

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[1] BOT. GAZ. 31:410. 1901.

A hypocotyl is practically absent in the Aesculus seedling, the root beginning hardly a millimeter below the insertion of the petioles of the cotyledons. The lower part of these petioles, however, grows more or less firmly into a tube by the coalescence of their margins. The curve may occur in this tube, as in the figured and measured specimens, or in the upper ends where they are usually separate. The tube entirely surrounds the plumule, and the curve is ordinarily far enough up in the petioles so that the lower end of them with the enclosed plumule is brought into the vertical line with the root.

The plumule being below the curve, and already in the vertical line, when it grows it does not escape from the petiole-tube by growing out of the top of it, but out through its side. It does not have to force this passage, which it could hardly do. But at the height where it is to escape, and on that side, there is a vigorous but strictly localized growth, without a corresponding elongation elsewhere in the same zone. The result is the same as when the two guard cells of a stoma with rigid, fast ends enlarge; they spread apart in the middle. In the same way the two petioles pull, or rather push, apart, opening a wide crack, often two or three times as wide as it need be, to permit the free growth of the plumule. What stimulus determines this remarkable localized growth I do not know.

This buckeye is very abundant here, and its large seeds with powerful roots make it an inviting subject for any work on the pressure exerted by the growing roots, or involving their mutilation. For these ordinary experiments on geotropism, reported here, it is well adapted, because it can easily be marked accurately, and especially because of the ease of fixing the position. The cotyledons are so large and heavy that it is only necessary to make plane the proper side and put the seedling down on that surface in a dish containing a little water. The plane of the cut surface determines the inclination of the growing region. If older seedlings are to grow downward, the cotyledons are cut in the same way and then placed on pedestals. When the whole active part of the seedling is under water growth ceases, but in moist air they do very well. Seeds kept some months in the very dry air of the laboratory refuse to germinate.—EDWIN BINGHAM COPELAND, *Stanford University*, *California.*

CONTRIBUTIONS TO THE BIOLOGY OF RHIZOBIA.

III. NOTES ON THE WINTER AND EARLY SPRING CONDITIONS OF RHIZOBIA AND ROOT TUBERCLES.

THE major observations here recorded were made during the winter and early spring of 1893 and 1894; incidental observations were also made during subsequent winter seasons. The object was to obtain more definite information regarding the permanency of leguminous root tubercles and the viability and natural resistance of rhizobia to low temperatures, more especially low temperatures with frequent changes to higher temperatures as in the winter months of the central states, Illinois in particular. Sudden changes of temperature, though not necessarily fatal to life, have a pernicious effect upon low organisms. The effects of temperature and other climatic conditions become gradually less with increase in depth of soil. The organisms found in the surface soil are most directly exposed to the pernicious climatic changes.

From the following table of mean monthly averages for the months of November, December, January, February, and March, 1902–3, with a list of coldest days of each month, it will be seen that the variation in temperature was considerable. Very cold weather (— 10° to — 15° F.) did not continue for more than a few days at a time.

Month	Min. ° F.	Max. ° F.	Mean ° F.	Coldest days ° F.
November	25.9	52.1	37.3	6, 10, 14, 16, 18, 18.
December	19.9	38.4	30.0	— 6, 1, 3, 5, 6, 6, 8, 9.
January	20.3	39.7	29.4	—21, —12, 12, 10, 12.
February	15.6	33.9	24.7	— 5, 2, 3, 3, 7, 8.
March............	32.9	55.6	43.5	10, 11, 12, 16, 21.

The humidity during the months indicated was somewhat above the average for the state of Illinois. The ground was covered with snow during parts of the months of January, February and March. Soil covered by snow banks was not frozen at any time. The open unprotected soil was frozen to a depth of about eighteen inches during January, February and the early part of March.